3/6/06 - 00714

Reisch, Timothy A CIV NAVFAC Lant

From: Franklin.Greyson@epamail.epa.gov
Sent: Monday, March 06, 2006 10:56 AM
To: Reisch, Timothy A CIV NAVFAC Lant; samihalko@deq.virginia.gov; Laura.Cook@CH2M.com; plandin@CH2M.com
Subject: NASO Statistical Review SWMUs 2B and 24 - EPA Las Vegas comments

Attachments: Las Vegas comments SWMU 2B and 24.doc

Las Vegas
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Team NASO,

Attached is a memo based on review of the (2)Tech Memos sent to EPA's Las Vegas Lab. Essentially the reviewers appear to concur in the Tech Memo premises. They have noted that the data column labels for SWMU 2B, Tables 1 and 2, are not correctly ordered. In addition, for both SWMUs, they have noted that the data sets are small and may not be reliable, and it may be desirable to collect more samples. We can discuss this.

If you have any questions or comments, please contact me.

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(See attached file: Las Vegas comments SWMU 2B and 24.doc)

Review of Statistical Analysis of Groundwater Arsenic Data for SWMU 2B and SWMU 24, Naval Air Station Oceana (NASO) Site Virginia Beach, Virginia

Anita Singh and Ellen Lee, Lockheed Martin
3-2-2006

In early Febrary 2006, Mr. G. Franklin of Region 3 requested the assistance of TSC-NERL, Las Vegas in reviewing the statistical approaches used in two technical memoranda (dated October 28, 2005 and August 23, 2005, respectively) prepared by CH2M HILL for the two Solid Waste Management Units: SWMU 2B and SWMU 24 of the NASO Site. Specifically, Mr. Franklin wants to know if the conclusions derived in these two memoranda based upon the statistical analyses of groundwater monitoring arsenic data sets are appropriate. This letter report summarizes the reviewers' comments on the statistical approaches used and conclusions derived in the two technical memos as prepared by CH2M HILL. An independent analysis of the arsenic data for the two SWMUs was also performed. Section A and Section B of this report, respectively provide reviewers' comments on the two memoranda for SWMU 2B and SWMU 24 of the NASO Site.

For the two SWM units, both dissolved and total arsenic concentration data sets have been considered to determine whether: 1) downgradient concentrations statistically exceed upgradient concentrations, and 2) other concentrations (from previous organic plume source and adjacent areas) exceed upgradient concentrations. For each of the SWM units (2B and 24), all duplicate samples were averaged, and non-detect values were replaced by ½ the respective detection limits.

Section A. Groundwater Arsenic Data Review and Statistical Analysis for SWMU 2B

The monitoring wells for unit SWMU 2B have been divided into three groups: upgradient wells, downgradient wells, and other wells (in previous organic plume source and adjacent areas). The grouping of monitoring wells is given by: upgradient (MW04, MW10, and MW11), downgradient (MW08, MW12, and MW19), and other (MW01, MW02, MW03, MW05, MW07, MW09, MW13, MW14, MW15, MW16, MW17, MW18, and MW20).

The arsenic concentration data were collected during two sampling rounds: 1993 and 2000. It is noted that for the 1993 sampling round, only a few observations are available (1 detect for the upgradient, 1 nondetect for the downgradient group, and 3 detects for other well group). No reliable statistical analysis can be conducted using such a small data set for sampling round of year 1993. Therefore, the data were combined together for the two sampling rounds: 1993 and 2000. The results are summarized in Tables 1 –3 of the CH2M HILL memo of 10-28-2005.

A quick review of the results presented in Tables 1 and 2, and the conclusions thus derived for SWMU 2B, reveals that some thing is not correct, causing some confusion for the reviewers. Specifically, the statistics as summarized in Tables 1 and 2 do not support the

conclusions derived in the memo prepared by CH2M HILL. This led us to review the raw data sets for the two units as provided by Mr. Franklin. In order to verify the results and the conclusions, the reviewers performed an independent analysis of the arsenic data sets for the two waste management units of the NASO Site.

It is noted that 16 samples are available for the other wells (3 samples from 1993 and 13 samples from 2000), but for some reason, one sample was not included in the analysis. Since no reason was mentioned for deleting one sample, all 16 samples were used for this review, which nevertheless doesn't affect the final conclusion. The nonparametric Mann-Whitney Test was used to compare the data sets: Downgradient vs. Upgradient, and Other vs. Upgradient. The statistical software Minitab was used. The detailed results are given in Appendix 1, Section A. The analysis was conducted for the combined data set of sampling rounds 1993 and 2000, and for data set from the sampling round for year 2000.

Results of the reviewers' analysis revealed that incorrect group labels have been used in the two summary statistics tables: Table 1 (Comparing 1993 and 2000 data) and Table 2 (Summary statistics for the combined data). Specifically, due to the use of incorrect labels, the conclusions derived were not supported by the statistics summarized in the two tables. The two tables from the CH2M HILL memo are included here. The correct order of labels in the following two tables is: Downgradient, Other, and Upgradient. Thus, in the following two tables, Upgradient should be replaced by Downgradient, Downgradient should be replaced by Other, and Other should be replaced by Upgradient.

Table 1: Summary Statistics Comparing 1993 and 2000 Data

		1993				2000			
Parameter	Grouping	Mean	Median	Number of Detects	Number of Analyses	Mean	Median	Number of Detects	Number of Analyses
Dissolved arsenic	Upgradient	0.3	0.3	0	1	2.3	2.5	1	3
	Downgradient	3.0	2.6	3	3	7.9	2.4	6	12
	Other *	3.9	3.9	1	1	6.2	4.3	3	3
Total arsenic	Upgradient	0.3	0.3	0	1	1.8	1.3	1	3
	Downgradient	3.1	2.5	3	3	8.5	3.6	7	12
	Other *	2.2	2.2	1	1	11.6	11.0	3	3

* Other = Source Area and Side Gradient

Table 2: Summary Statistics for Combined Data (1993 and 2000)

Parameter	Grouping	Mean	Median	Number of Detects	Number of Analyses
Dissolved arsenic	Upgradient	1.8	1.9	1	4
	Downgradient	6.9	2.6	9	15
	Other *	5.6	4.2	4	4
Total arsenic	Upgradient	1.4	1.3	1	4
	Downgradient	7.4	2.8	10	15
	Other *	9.2	9.9	4	4

* Other = Source Area and adjacent wells

Using the statistical analysis results of Section A, Appendix 1, the reviewers concur with the approaches used and conclusions derived by CH2M HILL. Based upon the limited data set available from the two sampling rounds, it can be concluded that: 1) downgradient concentrations do not exceed upgradient concentrations, and 2) also the arsenic concentrations from the other group of wells do not exceed the arsenic concentrations in upgradient wells.

Conclusion: Based upon the statistical results as summarized in Appendix 1, the reviewers concur with the conclusions derived by CH2M HILL. Based upon the limited data set collected, no significant differences in arsenic concentrations (total as well as dissolved) can be found in monitoring wells of the three groups.

However, it is desirable to collect more samples before taking a final decision, as the conclusions derived based upon small data sets may not be reliable. For an example, from informal graphical displays of Figures 2 and 3 of the CH2M HILL memo, it appears that the arsenic concentrations in monitoring wells from the source (Other) area may be higher than those found in the Upgradient wells. These observations can be confirmed by collecting more data from the various monitoring wells.

Section B: SWMU 24 Groundwater Arsenic Data Review and Statistical Analysis

For area SWMU 24, a similar statistical analysis (as conducted for SWMU 2B) was conducted using the arsenic data (both dissolved and total) collected during the sampling round for year 2004. For this SWM unit, the grouping for the three well categories is given by: Upgradient (MW05, MW06, MW10, and MW11), Downgradient (PZ01, PZ02, PZ03, MW02, MW03, MW08, and MW09), and Other (MW01 and MW04). Since only two samples are available from the Other group (source area) category, no statistical comparison was made between the "Other" and "Upgradient" well categories.

In order to verify the results and conclusions derived by CH2M HILL, an independent analysis was performed by the reviewers. The corresponding results obtained using the Minitab

software are given in Section B of Appendix A. It is noted that the mean and median values of Table 1: Summary Statistics by Grouping, are slightly different from the ones calculated by the reviewers. However, the conclusions derived do not change.

Conclusion: Based upon the statistical analysis results as summarized in Appendix 1, Section B, the reviewers concur with the conclusions as derived in the memo dated 8-23-2005 for the SWMU 24. Specifically, based upon the results of the Mann-Whitney test (Appendix 1, Section B), it can be concluded that arsenic (dissolved as well as total) concentrations in Downgradient monitoring wells do not exceed the arsenic concentrations in Upgradient wells.

However, it is desirable to collect more samples (e.g., from the "Other" source area) before making a final decision, as the conclusions derived based upon small data sets may not be reliable.

APPENDIX 1

Section A. Analysis for SWMU 2B - Results from Minitab

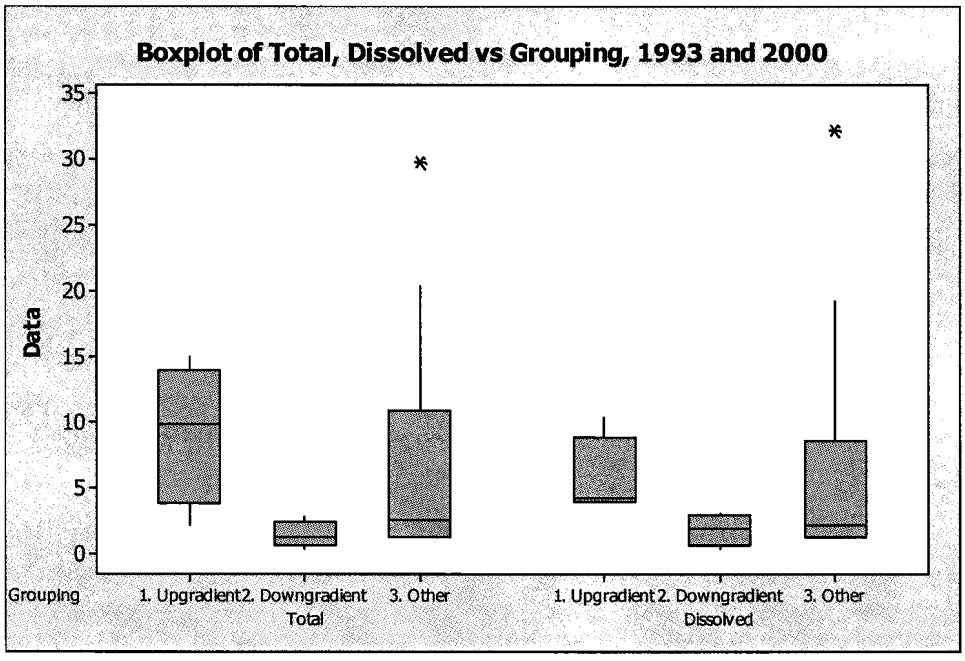
Summary Statistics of 1993 and 2000

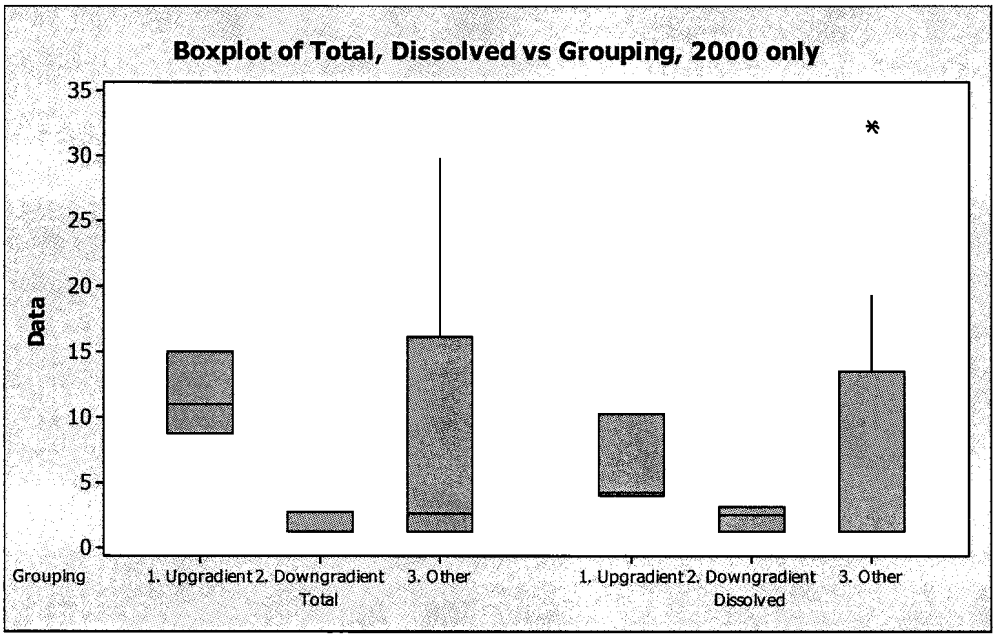
		Sample Year = 1993			Sample Year = 2000		
Variable	Grouping	Total Count	Mean	Median	Total Count	Mean	Median
Dissolved	1. Upgradient	1	3.9000	3.9000	3	6.20	4.30
	2. Downgradient	1	0.34000	0.34000	3	2.283	2.500
	3. Other	3	3.000	2.600	13	7.37	1.25
Total	1. Upgradient	1	2.2000	2.2000	3	11.57	11.00
	2. Downgradient	1	0.34000	0.34000	3	1.767	1.250
	3. Other	3	3.13	2.50	13	7.90	2.65

Summary Statistics of 1993 and 2000

Variable	Grouping	Count	Mean	Median
Dissolved	1. Upgradient	4	5.63	4.15
	2. Downgradient	4	1.798	1.875
	3. Other	16	6.55	2.20
Total	1. Upgradient	4	9.23	9.85
	2. Downgradient	4	1.410	1.250
	3. Other	16	7.01	2.58

Box Plots





The Mann-Whitney test Results

Arsenic, Total

1993 and 2000	2000 only
Upgradient vs. Downgradient	Upgradient vs. Downgradient
N Median Up_Total 4 9.850 Down_Total 4 1.250	N Median Up_Total 3 11.000 Down_Total 3 1.250
Point estimate for ETA1-ETA2 is 8.280 97.0 Percent CI for ETA1-ETA2 is (-0.601,14.663) W = 25.0 Test of ETA1 = ETA2 vs ETA1 < ETA2 Cannot reject since W is > 18.0	Point estimate for ETA1-ETA2 is 9.750 91.9 Percent CI for ETA1-ETA2 is (5.901,13.751) W = 15.0 Test of ETA1 = ETA2 vs ETA1 < ETA2 Cannot reject since W is > 10.5
Upgradient vs. Others	Upgradient vs. Others
N Median Up_Total 4 9.85 Other_Total 16 2.58	N Median Up_Total 3 11.00 Other_Total 13 2.65
Point estimate for ETA1-ETA2 is 5.35 95.8 Percent CI for ETA1-ETA2 is (-8.70,9.75) W = 54.0 Test of ETA1 = ETA2 vs ETA1 < ETA2	Point estimate for ETA1-ETA2 is 7.45 95.6 Percent CI for ETA1-ETA2 is (-11.00,13.75) W = 34.0 Test of ETA1 = ETA2 vs ETA1 < ETA2

Cannot reject since W is > 42.0	Cannot reject since W is > 25.5

Up&Other vs. Downgradient

	N	Median
Up&Other_Total	20	3.475
Down_Total	4	1.250

Point estimate for ETA1-ETA2 is 2.235
95.2 Percent CI for ETA1-ETA2 is (0.001,13.748)
W = 274.0
Test of ETA1 = ETA2 vs ETA1 < ETA2

Cannot reject since W is > 250.0

Up&Other vs. Downgradient

	N	Median
Up&Other_Total	16	5.150
Down_Total	3	1.250

Point estimate for ETA1-ETA2 is 3.125
96.1 Percent CI for ETA1-ETA2 is (-1.554,18.450)
W = 171.0
Test of ETA1 = ETA2 vs ETA1 < ETA2

Cannot reject since W is > 160.0

Arsenic, Dissolved

1993 and 2000	2000 only

Upgradient vs. Downgradient

	N	Median
Up_Dissolved	4	4.150
Down_Dissolved	4	1.875

Point estimate for ETA1-ETA2 is 2.900
97.0 Percent CI for ETA1-ETA2 is (0.800,9.962)
W = 26.0
Test of ETA1 = ETA2 vs ETA1 < ETA2

Cannot reject since W is > 18.0

Upgradient vs. Downgradient

	N	Median
Up_Dissolved	3	4.300
Down_Dissolved	3	2.500

Point estimate for ETA1-ETA2 is 2.750
91.9 Percent CI for ETA1-ETA2 is (0.901,9.049)
W = 15.0
Test of ETA1 = ETA2 vs ETA1 < ETA2

Cannot reject since W is > 10.5

Upgradient vs. Others

	N	Median
Up_Dissolved	4	4.15
Other_Dissolved	16	2.20

Point estimate for ETA1-ETA2 is 2.65
95.8 Percent CI for ETA1-ETA2 is (-8.90,5.70)
W = 53.0
Test of ETA1 = ETA2 vs ETA1 < ETA2

Cannot reject since W is > 42.0

Upgradient vs. Others

	N	Median
Up_Dissolved	3	4.30
Other_Dissolved	13	1.25

Point estimate for ETA1-ETA2 is 2.75
95.6 Percent CI for ETA1-ETA2 is (-14.90,9.05)
W = 32.0
Test of ETA1 = ETA2 vs ETA1 < ETA2

Cannot reject since W is > 25.5

Up&Other vs. Downgradient

Up&Other vs. Downgradient

	N	Median
Up&Other_Dissolved	20	3.700
Down_Dissolved	4	1.875

Point estimate for ETA1-ETA2 is 1.430
95.2 Percent CI for ETA1-ETA2 is (-1.252,9.051)
W = 269.5
Test of ETA1 = ETA2 vs ETA1 < ETA2

Cannot reject since W is > 250.0

	N	Median
Up&Other_Dissolved	16	3.750
Down_Dissolved	3	2.500

Point estimate for ETA1-ETA2 is 1.100
96.1 Percent CI for ETA1-ETA2 is (-1.849,16.102)
W = 166.5
Test of ETA1 = ETA2 vs ETA1 < ETA2

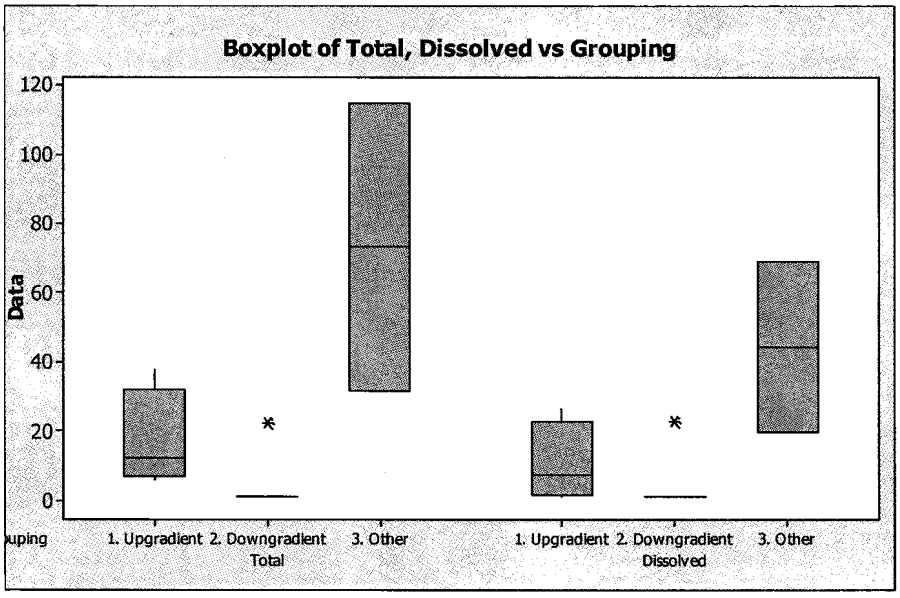
Cannot reject since W is > 160.0

Section B. Analysis for SWMU 24 - Results from Minitab

Summary Statistics - Sampling Round for Year 2004

Variable	Grouping	Total Count	Mean	Median
Total	1. Upgradient	4	17.11	12.35
	2. Downgradient	7	4.46	1.45
	3. Other	2	73.4	73.4
Dissolved	1. Upgradient	4	10.76	7.59
	2. Downgradient	7	4.47	1.45
	3. Other	2	44.5	44.5

Box plot



The Mann-Whitney test Results

Arsenic, Total	Arsenic, Dissolved
Upgradient vs. Downgradient	Upgradient vs. Downgradient
N Median Up_Total 4 12.35 Down_Total 7 1.45 Point estimate for ETA1-ETA2 is 7.95 95.3 Percent CI for ETA1-ETA2 is (4.49,36.34) W = 35.0 Test of ETA1 = ETA2 vs ETA1 < ETA2 Cannot reject since W is > 24.0	N Median Up_Dissolved 4 7.59 Down_Dissolved 7 1.45 Point estimate for ETA1-ETA2 is 0.88 95.3 Percent CI for ETA1-ETA2 is (-0.01,24.95) W = 32.0 Test of ETA1 = ETA2 vs ETA1 < ETA2 Cannot reject since W is > 24.0
Up&Other vs. Downgradient	Up&Other vs. Downgradient
N Median Up+Other_Total 6 23.50 Down_Total 7 1.45 Point estimate for ETA1-ETA2 is 13.85 96.2 Percent CI for ETA1-ETA2 is (4.50,92.50) W = 60.0 Test of ETA1 = ETA2 vs ETA1 < ETA2 Cannot reject since W is > 42.0	N Median Up+Other_Dissolved 6 16.38 Down_Dissolved 7 1.45 Point estimate for ETA1-ETA2 is 11.40 96.2 Percent CI for ETA1-ETA2 is (-0.00,46.40) W = 56.0 Test of ETA1 = ETA2 vs ETA1 < ETA2 Cannot reject since W is > 42.0